NORMAL AND SURGICAL ANATOMY OF THE VERMIFORM APPENDIX.

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FROM

THE MEDICAL NEWS,

May 4, 1895.

[Reprinted from THE MEDICAL NEWS, May 4, 1895.]

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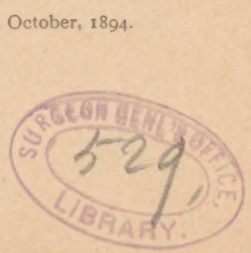
THE results chronicled in this paper were drawn almost entirely from various post-mortem examinations and from practical work in the dissecting-room. The specimens are the more varied and peculiar of those prepared. Each consists of the cecum, a portion of the ileum and colon, the attached peritoneum, and the appendix. Measurements and other observations were first taken *in situ*. After removal a fresh specimen was soaked in warm water for a few hours, then in a one per cent. solution of mercuric chlorid for a day, and afterward immersed in glycerol. In this manner the bowel retains an elastic and natural state of preservation.

During development of the alimentary canal a diverticulum is noticed separating the small and large bowel in the region later occupied by the ileo-cecal valves. The lower part of this loop re-

[1] Read before the London Medical Society, October, 1894.



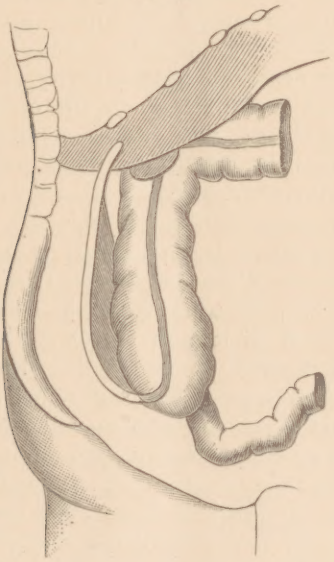
mains comparatively small; the proximal portion enlarges to form the dilated cecum, probably about the sixth week of fetal life. All this takes place on the left of the median line of the abdomen, but in the process of development gradually crosses over toward the liver. At the sixth month the cecum is found in its most frequent location in the right iliac fossa. This peculiar translation will account for the varied positions of the appendix in the abdominal cavity, because it may be arrested in the median line near the liver, or even extend into the pelvic cavity. Indeed, it is frequently found in close relation to the rectum, uterus, or bladder, without showing any signs of having been changed to an abnormal position by cicatricial tissue. Although six months is the average time for its descent, I once found the cecum high up behind the right hepatic lobe in an eight-months' fetus, although this is often more apparent than real on account of the enormous size of the liver.

In a case that developed pus, reported by Dr. H. A. McCallum, of London (THE MEDICAL NEWS, December 17, 1892), the appendix was situated on and adherent to the upper surface of the liver. An eminent authority, Mr. Treves, of London, supposed that this condition has arisen from arrested descent of the large bowel. It may well be questioned how the appendix could possibly lie in such a position except in the foregoing manner, unless drawn upward by cicatricial tissues, or indeed if the liver were not enlarged or floated downward. This specimen (Fig. 1), however, will easily persuade you that such a condition may and does happen with a

normally placed cecum, the appendix being very long and lying on the liver above the gall-bladder.

When the abdomen is incised the parietal layer of the peritoneum will be divided and the peritoneal cavity opened. If the omentum and intes-

FIG. 1.



tines are pushed aside, the visceral layer can be traced upward from the pelvic organs to the right iliac fossa, approaching quite close to Poupart's ligament and covering the psoas and iliac muscles. On reaching the highest limit of the under surface of the cecum it bends forward and downward to

cover its pouch-like blind extremity, and, meeting with the appendix, completely invests it to the tip as well as being reflected over the front of the cecum to cover the ascending colon where it is continuous with the parietal layer from the side of the abdominal wall.

The cecum, then, is in nearly every case totally invested by peritoneum, lies quite loosely in its position, and is freely movable. The appendix now floats in the general peritoneal cavity with a mesentery that not only binds it to the caput coli, but also to the mesentery of the small intestine as it passes behind the distal end of the ileum. The appendix is, therefore, in nearly all cases, intra-peritoneal, is occasionally in the peritoneum *in toto*, but more frequently its base for a half or one inch is extra-peritoneal while the remainder is intra-peritoneal. The peritoneum from the cecum arches over the ileum to join the great mesentery, often forming a complete bridge, under which the ileo-cecal junction disappears when sufficient air is injected into the colon. This so-called normal position of the cecum, then, is on the front and outer edge of the psoas muscle internally and the iliacus externally. It lies in a line drawn vertically upward from the center of Poupart's ligament, and its lowest border is almost on a level with the anterior superior spines of the ilia. This is subject, however, to remarkable variations, readily explained by a consideration of its development. Indeed, a rather long appendix is often found dipping down into the true pelvis, lying on the iliac vessels, the obturator and genito-crural nerves, and in the

female bearing important relations to the broad ligament and the right ovary. It may also point in various directions even when the position of the caput coli itself is normal. Sixty-four per cent. of my cases showed it to lie in the recognized position, either being curled on itself or pointing toward the sacro-vertebral angle. More than half the remainder lay on the psoas and hung into the pelvic cavity. The rest projected at various angles, either toward the pubes, the internal abdominal ring, the anterior superior spine of the ilium, or upward and outward parallel with the ascending colon. In one instance, an old case of hernia, it lay in the scrotum, with the cecum and five feet or more of the ileum, and was adherent (a very rare condition), with the rest of the bowel, to the sac.

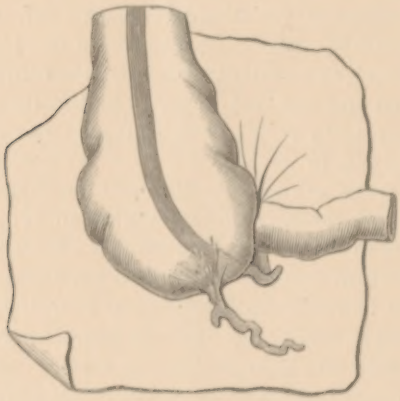
Analysis of my specimens gave an average measurement of three-and-a-half inches in the female and three in the male. The shortest was only three-quarters of an inch. One was bifid, being represented by two little buds jutting out from the bowel. The longest was seven inches, possessed no mes entery, and was attached to the cecum and colon to within half-an-inch of the tip. One specimen was no larger than a knitting-needle, but was four-and-a-half inches in length.

The lumen is generally small, with its sides in apposition. In one case the interior was as large as the index-finger, and was completely filled, for quite an inch, with hard fecal matter, but no symptoms had been complained of during life from this condition.

A mesentery is generally present, and often gives

the appendix remarkable latitude. Sometimes a large deposit of fat lies on the appendicular mesentery, and an elongated layer will simulate the appendix (Fig. 2). From the base of the appendix to the angle formed by the bend of the peritoneum, which is reflected over the end of the cecum from the iliac fossa, the average measurement was one-and-a-half inches.

FIG. 2.



The structure, therefore, lies in a pouch much like a small pocket, bounded above and in front by the cecum, behind by the angle of peritoneum, and internally by the last inch of the ileum and the raised border of the psoas muscle. The opening into the cecum is quite readily seen, and is situated by average measurement rather more than one inch from the ileo-cecal mouth, and is guarded generally

by an incomplete valve of mucous membrane, the good service of which is very doubtful. This seems not to be a regularly constituted valve, but a mere puckering of the mucous membrane. It is formed probably much in the same way as a hemorrhoid is enlarged by pressure. It is, at any rate, incapable of preventing air or feces from entering the lumen of the appendix.

In all cases the anterior band of fibers, which is characteristic of the large bowel, runs over the cecum and on to the vermiform process. It spreads out, as in the rectum, to form part of its structure, so that when from some cause the appendix cannot be found this longitudinal muscular band should be traced to its termination. It is quite half-an-inch in width and easily recognized.

The pocket of peritoneum in which the appendix lies is usually very thin, more markedly so than in any other region. In all the prepared specimens the serous membrane was very elastic, and when stretched to a considerable distance easily returned to its normal condition. Too much extension, however, destroyed this elasticity.

These experiments will serve to explain the enormous pouches found in some herniæ.

My dissections of the fetus at various stages of development offer marked contrasts to those of the adult. About the sixteenth week the liver fills almost the whole abdominal cavity, and when the parietes are removed only a few small intestines are seen peeping out from beneath its lower border. When this organ is turned up (Fig. 3) there seems to be no difference between the ascending colon

and transverse colon, for the large bowel lies in an almost horizontal direction. The kidney is very large, and is easily seen through the thin transparent peritoneum. The appendix, instead of being attached like a small bud shooting out from a large trunk, as in the adult, in reality tapers off like a veri-

FIG. 3.

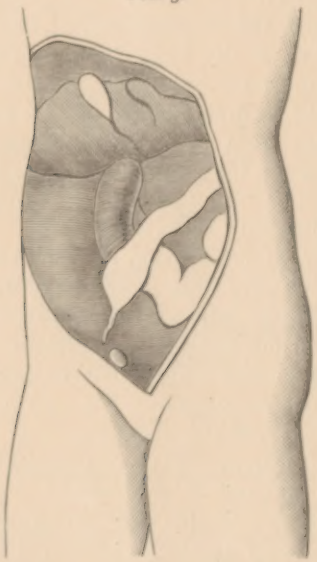


table continuation. No appreciable constriction is present as a line of demarcation, its base being of the same size as the cecum. Most of these processes were remarkably long in comparison with the rest of the intestinal tract.

As the organ is of the same size as the cecum at the

fourth month and earlier, this fact tends to support the view that it is but a retrograde metamorphosis of that portion of the bowel. The duodenum is now the largest portion of the alimentary canal, the jejunum next, while the ileum, though much smaller than the former, is still larger than the colon. The testicle is found lying in the iliac fossa near the internal ring, through which it soon passes on its way to the scrotum.

The arterial supply to the appendix is derived generally from the ileocolic artery, occasionally a special branch of the superior mesenteric itself. The little vessel runs on to the appendicular mesentery at its free border and spreads over its surface much in the same manner as in the ileum and colon. This is beautifully demonstrated in the thin transparent peritoneum of the fetus. In one well marked case smaller vessels were traced upward in the serous membrane from the iliac fossa, derived probably from the external iliac or deep external iliac arteries. Its nervous mechanism is doubtless derived from the same source as the adjacent portions of the intestine, viz.: the intrinsic ganglia connected first with the sympathetic on the superior mesenteric artery, thence to the solar plexus and the splanchnics, the great and lesser.

It is evident, then, that vasomotor disturbances would equally affect the appendix with the general supply, except that its tendency to a retrograde metamorphosis has already altered the normal condition of its nerves.

Whatever may be the real condition setting up inflammation in this region, the appendix is in

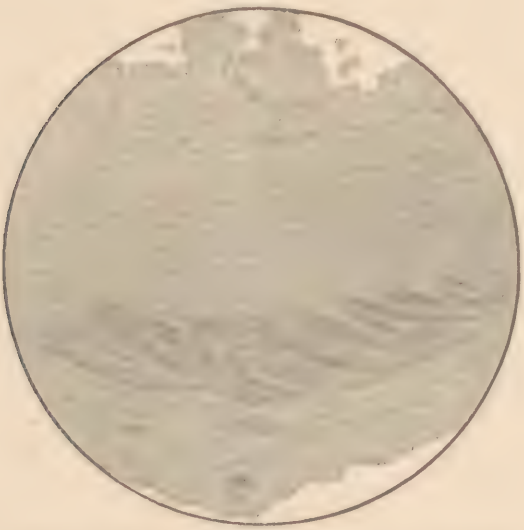
the majority of cases the seat of the trouble. It would seem reasonable to suppose that the cases that develop inflammation and get well in a few days should be due to the cecum, and the more serious cases leading to suppuration to the appendix. The bowel has a powerful peristaltic action to beat on the fecal material, and so aids evacuation; but the appendix is rarely relieved of its contents in this manner. The circular muscular coat is comparatively meager in the appendix, but by no means totally absent, as some have asserted; in fact, it was in one case of appendicitis much thickened, as well as the mucosa. Doubtless the appendix endeavors to rid itself of foreign material by contractions analogous to the vermicular action of the rest of the alimentary tract, and colic results.

The objection that has been raised to the occurrence of appendicular colic is that the circular coat is too meager to cause spasm. But it seems that it may hypertrophy under irritation, as it appears to have done in one particular case, that of Miss R., a patient of Dr. H. A. McCallum, who kindly gave me a portion of the appendix, which we both prepared microscopically, finding the circular muscular coat greatly thickened, and representing quite a third of the whole (Fig. 4) appendicular wall. This patient presented a history of six attacks of apparent appendicitis (appendicular colic) during two years.

It would, therefore, seem right to praise any medical means directed to the prevention of a loaded cecum. By this the incipient foreign irritant of whatever nature would have less opportunity of in-

sinuating itself too far into the opening of the appendix, as sometimes happens. Impaction of feces may not necessarily lead to any disturbance whatever, as in a few of my cases the lumen was completely filled with hardened contents of the intestines, yet without previous complaint of symptoms.

FIG. 4.



Showing exudation of leukocytes between the muscle-fibers, as well as in the lymphoid tissue.

Appendicitis may well be mistaken for perinephric abscess, because there is in many cases but little distance between the appendix and the lowest portion of the right kidney. A localized pain in the

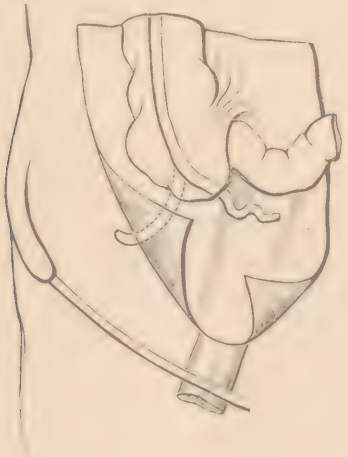
right iliac fossa, however, arises from many other causes, the appendix being no more to blame than a molar in facial neuralgia. This suspicion is heightened when we notice that in most of the specimens examined, death resulting from other causes, no adhesions or other signs were present. It seems that most of the bad cases are due to the vermiform process, because material once firmly impacted has but little chance of removal. This nidus would offer a suitable colony for germs. Foreign bodies are found sometimes, and perhaps lead to suppuration more frequently than is supposed. During the evacuation of pus may they not be sometimes entirely overlooked and the trouble referred to some other cause?

If the appendix be really but a remnant, like many organs undergoing a retrograde evolution, it is liable to be inflamed. This may be due to a natural tendency, as the tail of a tadpole is removed for the purpose of inaugurating a new and more perfect era in the future life of the animal.

The question is often asked where the abscess forms in suppurative appendicitis. By this is meant after perforation has taken place. This will depend, of course, upon the position of the appendix and its relation to the peritoneum. If it be situated entirely behind, the angle of the serous membrane will be in front and the abscess will be retroperitoneal (Fig. 5). The cases in which the appendix is uncovered are the rarest. The first half inch of its base is often behind the peritoneum, and perforation here would lead to a collection of pus behind. If it be invested entirely with serous

membrane, as is the usual condition, it will be within the general cavity, and ulceration in any part of its course will lead to an intraperitoneal tumor. There are two or three reasons why this latter condition is not always present:

FIG. 5.



1. It is seen that the first half-inch is often uncovered, and perforation in that part would lead to a collection in the connective tissue behind the cecum.

2. The mesentery is often short and sometimes absent, the appendix being closely adherent to the bowel. Perforation may lead to a discharge by the rectum, as frequently occurs.

3. Even when five inches or more in length, situated entirely within the cavity and having an elon-

gated mesentery, a retroperitoneal abscess often occurs. Although the appendix would seem to have a perfectly wide range of liberty, yet in the natural condition no space whatever is allowable. All parts of the viscera, intestines, omentum, and parietes are closely pressed together in the same manner as the urethra is when at rest. The appendix will then, of course, lie in perfect apposition with the posterior layer of peritoneum and in front to the small intestine. Ulceration taking place in the posterior wall, leads to a matting of the appendix and the peritoneum, both layers are involved, and the abscess becomes retroperitoneal. This, in its turn, may again burst back and become intraperitoneal, or work its way in various directions. It would seem reasonable to suppose at first sight that when an intraperitoneal abscess is formed death would rapidly ensue. On account of close apposition of the structures the lymph thrown out during the inflammatory process forms a barrier or capsule that prevents general infection. If perforation took place suddenly, with overflow of pus, collapse would probably immediately occur. In one case only this wall or capsule was thick and as hard as cartilage.

A swelling in the right iliac fossa, then, may be due to many different causes, and any one of them, as far as the anatomy of the parts is concerned, may set up very similar symptoms. As the usual position of the cecum is on the front and outer edge of the psoas muscle, and also on the iliacus, and almost immediately above the center of Poupart's ligament, it will bear important relations to the following structures:

I. The ilioinguinal and iliohypogastric nerves, irritation of which would cause altered sensation in the lower parts of the abdominal wall, the iliac crest, and the inner side of the thigh. There may also be rigidity of the muscles in this region.

II. The external cutaneous and anterior crural, affecting sensation on the outer part and front of the thigh and the inner side of the leg below the knee. Pain in the knee-joint or spasm of the prefemoral muscles may follow, and there may be retraction of the testicle from involvement of the genito-crural; or, also, affections of the adductors of the femur, with possible hip-trouble through the obturator nerves. In a young man of twenty-two years hyperesthesia of the prefemoral region was a prominent symptom.

We may also have urinary symptoms from proximity of the kidney and ureter, flexion of the thigh by irritation of the psoas, altered circulation in the iliac and spermatic vessels, and perhaps obstruction of the inferior vena cava.

If, then, the cecum is so loosely connected in the peritoneal cavity as to be found in almost any position, pus will also be found in regions far removed from those where the appendix is expected to lie. Adhesions to an ovarian cyst have greatly complicated an ovariotomy. In an operation for hematosalpinx, with removal of the right tube and ovary, the appendix was found to be inflamed, and was removed. There was a distinct connection in this case between the two by a structure analogous to the so-called appendiculo-ovarian ligament.

This specimen (see Fig. 1), 6½ inches in length,

lay external and parallel to the ascending colon, with its apex resting on the anterior surface of the liver, above the gall-bladder. Abscess might have occurred in front or behind the hepatic lobe, involving the pleura or lung, without the real cause of the trouble being suspected.

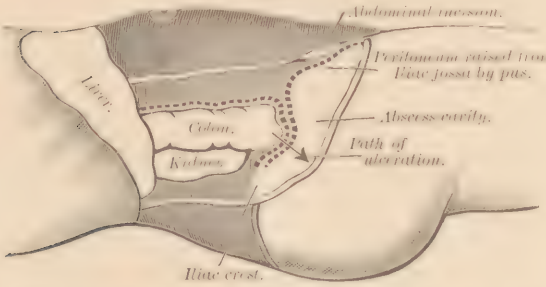
As pus may be found in almost any position, the incision is to be made directly over the most prominent part and the pus evacuated. The most important anatomic structure to locate is the deep epigastric artery, which ascends upward and inward to the outer edge of the rectus abdominis muscle. If the knife be kept external to a line from the center of Poupart's ligament to the umbilicus, no danger will be likely to occur from this vessel. If it should be cut, the incision should immediately be enlarged and both ends tied. This is necessary on account of the free inosculation it has with the superior epigastric branch of the internal mammary.

As exhaustion is a frequent cause of death, may not an early operation better be performed immediately when pus has been found present? Delay is certainly dangerous when an abscess is burrowing in close proximity to such a highly inflammable and important structure as the peritoneum.

As the cæcum rests below the crest of the ilium, if excision be decided upon, operation from behind would fail to reach the appendix in a satisfactory manner. In case of abscess, though the pus burrows backward as well as downward in the recumbent position, drainage from behind would be facilitated by a posterior incision (Fig. 6) in the lumbar region. The bottom of the abscess cavity is by actual

measurement 2½ inches, or even more, below the incision in front and above Poupart's ligament. In a boy of eight years of age, a patient of Dr. Balfour, drainage was effected behind and close to the iliac crest, with rapid recovery, the little fellow leaving the hospital within a month.

FIG. 6.



This lumbar opening, though, carries a risk. Post-mortem appearances show that operation for suppurative appendicitis should be conducted by the surgeon with the greatest care. Manipulation by insertion of the finger to hunt for some satisfactory solution of the condition might easily break down an extremely thin partition. Indeed, rather than use such force, would it not be better simply to incise the bulging part as one does an ordinary abscess in other regions? This may be done without washing out with syringe or other instrument, followed by a dressing with antiseptic absorbent material. Nature will undoubtedly endeavor to provide resolution in the same manner as when a boil is lanced, if good drainage is used. In other

words, in too much manipulation lies the danger of breaking down the natural wall and setting up general peritoneal infection. This appeals to us more forcibly when we remember that the pouch like cavity of peritoneum in which lies the appendix is the thinnest portion of serous membrane in the vicinity. The lymph-wall is occasionally so thin that the gentlest touch with the handle of the scalpel is sufficient to tear the tissue and allow pus to enter the general cavity. How important it is, then, to be extremely cautious!

The colon has a mesentery, a mesocolon, and this was present in 30 per cent. of my cases. When very long it may implicate matters somewhat in drainage from behind. In my experiments (post mortem) injection of the colon *in situ* with water or air invariably rotated the cecum outward, where it lay quite close to the anterior superior spine and crest of the ilium. If filled with feces or gas, it is very likely the tumor would be felt much nearer this region than in affections of the appendix; injection also caused the bowel to overlap the appendage, completely burying it behind the dilated coils, and in some cases entirely twisting the mesentery. This condition, taking place during life from large collections of gas, would possibly shut off the blood-supply to the process. The artery comes from the large mesentery, and lies behind the distal end of the ileum, where pressure would be liable to cause obstruction. The injected air not only enters the cecum, but the appendix as well, completely filling its lumen to the tip, offering further means for twists

and pressure. In only a few cases did this experiment fail.

Whether air or gas ever enter the appendix during life is a question, but this may be tried with some profit on the ape or wombat, animals that are scarce in this vicinity. This may have some small place in setting up trouble by volvulus and pressure. Hence an altered blood-supply in an organ that is ever ready, as is said, on account of its retrograde tendency to spontaneous combustion, would be the result.

If this evolutionary theory be a correct one, the arteries and nerves have, perhaps, a tendency to degeneration, and the resisting powers of the appendix are lessened; hence, all such causes as twists and pressure predispose to trouble. When it is remembered that the appendage lies in a small pocket-like cavity, may not intermittent pressure from the impacted large bowel act in a similar manner? In one operation undertaken for recurrent attacks by Dr. John Wishart at St. Joseph's Hospital nothing whatever was found in the lumen, no glands in the vicinity were enlarged, and yet the distal portion was as large as the thumb, with its mucosa much thickened and inflamed. This lay immediately behind the cecum and wedged down in the bottom and angle of the pouch of peritoneum. Constipation was present.

When it is found necessary to open the abdomen, apart from a bulging abscess, some difficulty may be experienced in locating the exact position of the appendix even in the cadaver. If the incision be made in the median line, this will be increased, be-

cause the operator is wide of the mark, and the only structures seen are the omentum and numerous coils of small intestine. The best procedure would be, if possible, to lay open the abdomen in the right linea semilunaris. The ascending colon will be seen lying on the right side, and is recognized by its large size, sacculated appearance, more fixed and constant position, and a prominent band of longitudinal muscular fibers. This is half an inch in width and extending the whole length. Still, after this has been located the appendix may not come into view, even after lifting the lower end of the cecum and turning it inward. There may be bands of cicatricial tissue, or the appendix may be in an abnormal position. Sometimes an elongated piece of peritoneum or a diverticulum filled with fat has presented a similar appearance (Fig. 2). This has been so marked as to be entirely mistaken for the appendix in the post-mortem room and by students at the examinations, much to their disgust and my amusement. But one young gentleman was wise enough to incise the cecum and obtain the appendicular outlet. The specimen presented is a good representation of how this difficulty may arise, as the appendix is no larger than an ordinary knitting-needle. The specimen would be markedly similar when viewed through a deep incision, as it lies in the bottom of a deep, dark cavity, buried among numerous coils of intestine. But there is always one unfailing method, and that is, to follow down the anterior band of longitudinal muscle-fibers of the colon, which shows distinctly through the serous covering. In every dissection this was traced to the

base and wall of the appendix, which it formed. When the appendix lies externally and ascends toward the liver the relative position of its internal opening to that of the ileum is still unaffected. The cecum is twisted a little outward at the base, and this band, instead of turning inward, follows its unfailing pathway to wherever the worm-like process lies.

CONCLUSIONS.

1. The development of the alimentary canal readily explains abnormal positions.

2. At the twelfth and sixteenth weeks there seems to be no difference in size between the base of the appendix and the cecum.

3. Prior to the sixth and seventh months the cecum and appendix lie well up in the abdomen, behind the liver or median line.

4. The appendix is nearly always found covered by peritoneum, and in most cases possessed of a mesentery.

5. There is generally a well-marked muscular circular coat.

6. The relative measurements between the exit of the appendix and the ileum are pretty constant.

7. The appendicular artery lies behind the distal portion of the ileum, and is accessible to pressure.

8. The wall of the appendix is always formed by the anterior band of muscular fibers from the cecum.

9. The appendix is readily filled with air from the cecum. In only a few cases did this fail.

10. From its position in a pocket-like cavity it is accessible to pressure from an impacted large bowel.

11. Feces collected in the lumen of the appendix do not necessarily set up any pathologic disturbance.

12. Air or fluid injected into the large bowel invariably rotates the cecum outward, in close relation to the anterior superior spine and crest of the ilium.

13. In this experiment the appendix is often dragged into abnormal positions and twisted on itself.

14. When ulceration takes place, with extraperitoneal formation of pus, two layers of serous membrane are involved if the appendix be intraperitoneal. Anatomically, it is possible for pus to separate the layers of the appendicular mesentery.

15. The lowest part of the abscess cavity in the recumbent position is two or three inches on a lower level than the incision in front and above Poupart's ligament.

16. An intimate relation sometimes exists between the tubes and ovaries with the appendix. In such a case suppurative appendicitis and hematosalpinx were both present, though no distinct suppurating tract could be traced between them.

17. A swelling in the right iliac fossa will give rise to similar symptoms from like anatomic relations to important viscera, vessels, and nerves.

18. When a large collection of pus has formed in the iliac fossa a tender spot may generally be felt in the lumbar region on the crest of the ilium, close to the sacro iliac articulation. A downward incision at this point will be sufficient to evacuate the abscess.